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(71) Applicant *(for all designated States except US)*: NORSK HYDRO ASA [NO/NO]; N–0240 Oslo (NO).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: GAUDERNACK, Gustav [NO/NO]; Anthon Walles vei 17 A, N–1300 Sandvika (NO). ERIKSEN, Jon, Amund [NO/NO]; Bjørntvedt gt. 37, N–3916 Porsgrunn (NO). MØLLER, Mona [NO/NO]; Skrukkerødtoppen 8, N–3925 Porsgrunn (NO).

(74) Agent: LILLEGRAVEN, Rita; Norsk Hydro ASA, N–0240 Oslo (NO).

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(54) Title: FRAMESHIFT MUTANTS OF BETA–AMYLOID PRECURSOR PROTEIN AND UBIQUITIN–B AND THEIR USE

(57) **Abstract**

Frameshift Mutants β–Amyloid precursor peptides and mutant ubiquitin–B associated with Alzheimer's disease and Down syndrome eliciting T cellular immunity for use in compositions for the treatment and/or prophylaxis of Alzheimer's disease and/or Down syndrome.

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FRAMESHIFT MUTANTS OF BETA-AMYLOID PRECURSOR PROTEIN AND UBIQUITIN-B AND THEIR USE

The present invention relates to peptides for treatment and/or prophylaxis of Alzheimer's disease and Down syndrome.

Alzheimer's disease and treatment of Down syndrome are both associated with frameshift mutations occurring at the transcriptional level or by posttranscriptional editing of RNA during the encoding of β-Amyloid precursor protein (βAPP) and ubiquitin-B (Ubi-B). Such frameshift mutations give rise to mutant βAPP and Ubi-B protein products which are characterised by aberrant protein sequences at the carboxyl terminus. Peptides covering, either completely or parts of, the aberrant parts of mutant βAPP or Ubi-B protein products elicit T cellular immunity and can therefore be useful in compositions for the treatment of Alzheimer's disease and Down syndrome. Further the peptides of this invention can be used as a prophylaxtic anti-Alzheimer's disease vaccine.

The invention also relates to DNA sequences encoding peptides corresponding to aberrant βAPP and Ubi-B protein sequences found in Alzheimer's disease and Down syndrome patients, and to vectors comprising at least one insertion site containing a DNA sequence encoding at least one such peptide.

Further the invention relates to methods for the treatment and/or prophylaxis of Alzheimer's disease by administration of at least one mutant βAPP and/or Ubi-B peptide or a recombinant virus vector comprising at least one insertion

site containing a DNA sequence encoding at least one mutant βAPP and/or one mutant Ubi-B peptide.

The present invention represents a development of a treatment and/or prophylaxis for Alzheimer's disease based on the use of peptides to generate activation of the T cellular arm of the body's own immune system against cells producing mutant βAPP and Ubi-B protein products associated with Alzheimer's disease.

The development and use of the methods for treatment of Alzheimer's disease may also be directly applicable for treatment of patients with Down syndrome.

Technical Background

Peptides corresponding to aberrant protein sequences resulting from frameshift mutations in genes in cancer cells elicit specific T cellular immunity and can be used as anti-cancer vaccines (ref. Norwegian patent applications filed at the same date as the present application by Norsk Hydro ASA). In the same manner peptides corresponding to aberrant protein sequences resulting from frameshift mutations associated with other diseases can be used to develop treatments of that diseases based on generation of specific T cellullar immunity.

Frameshift mutations result in completely new amino acid sequences in the C-terminal part of the proteins, prematurely terminating where a novel stop codon appears. This results in two important consequences:

1) The truncated protein resulting from the frameshift is generally nonfunctional, in most cases resulting in "knocking out" of an important cellular function. Aberrant

proteins may also gain new functions such as the capacity to aggragate and form plaques. In both cases the frameshift results in disease.

2) The aberant new C-terminal amino acid sequence resulting from the frameshift is foreign to the body. It does not exist prior to the mutation, and it only exists in cells having the mutation.

Since the mutant part of the proteins proteins are completely novel and therefore foreign to the immune system of the carrier, they may be recognized by T-cells in the repertoire of the carrier. So far, nobody has focused on this aspect of frameshift mutations, and no reports exist on the characterization of frameshift peptides from coding regions of proteins as antigens. This concept is therefore novel and forms the basis for developing vaccines based on these sequences. It follows that such vaccines may also be used prophyllactively in persons who inherit defective genes or in other ways are disposed for frameshift mutations. Such vaccines will therefore fill an empty space in the therapeutic armament against inherited forms of disease.

It has been shown that single amino acid substitutions in intracellular "self"-proteins may give rise to tumour rejection antigens, consisting of peptides differing in their amino acid sequence from the normal peptide. The T cells which recognise these peptides in the context of the major histocompatibility (MHC) molecules on the surface of the tumour cells, are capable of killing the tumour cells and thus rejecting the tumor from the host.

In contrast to antibodies produced by the B cells, which typically recognise a free antigen in its native conformation and further potentially recognise almost any

site exposed on the antigen surface, T cells recognise an antigen only if the antigen is bound and presented by a MHC molecule. Usually this binding will take place only after appropriate antigen processing, which comprises a proteolytic fragmentation of the protein, so that the resulting peptide fragment fits into the groove of the MHC molecule. Thereby T cells are enabled to also recognise peptides derived from intracellular proteins. T cells can thus recognise aberrant peptides derived from anywhere in the cells, in the context of MHC molecules on the surface of the cells, and can subsequently be activated to eliminate the cells harbouring the aberrant proteins.

M.Barinaga, Science, 257, 880-881, 1992 offers a short review of how MHC binds peptides. A more comprehensive explanation of the Technical Background for this Invention may be found in D. Male et al, Advanced Immunology, 1987, J.B.lippincott Company, Philadelphia. Both references are hereby included in their entirety.

The MHC molecules in humans are normally referred to as HLA (human leukocyte antigen) molecules. They are encoded by the HLA region on the human chromosome No 6.

The HLA molecules appear as two distinct classes depending on which region of the chromosome they are encoded by and which T cell subpopulations they interact with and thereby activate primarily. The class I molecules are encoded by the HLA A, B and C subloci and they primarily activate CD8+ cytotoxic T cells. The HLA class II molecules are encoded by the DR, DP and DQ subloci and primarily activate CD4+ T cells, both helper cells and cytotoxic cells.

Normally every individual has six HLA Class I molecules, usually two from each of the three groups A,B and C. Correspondingly, all individuals have their own selection

of HLA Class II molecules, again two from each of the three groups DP, DQ and DR. Each of the groups A, B, C and DP, DQ and DR are again divided into several subgroups. In some cases the number of different HLA Class I or II molecules is reduced due to the overlap of two HLA subgroups.

All the gene products are highly polymorphic. Different individuals thus express distinct HLA molecules that differ from those of other individuals. This is the basis for the difficulties in finding HLA matched organ donors in transplantations. The significance of the genetic variation of the HLA molecules in immunobiology is reflected by their role as immune-response genes. Through their peptide binding capacity, the presence or absence of certain HLA molecules governs the capacity of an individual to respond to peptide epitopes. As a consequence, HLA molecules determine resistance or susceptibility to disease.

T cells may control the development and growth of cells producing abberant proteins by a variety of mechanisms. Cytotoxic T cells, both HLA class I restricted CD8+ and HLA Class II restricted CD4+, may directly kill cells carrying the appropriate antigens. CD4+ helper T cells are needed for cytotoxic CD8+ T cell responses as well as for antibody responses, and for inducing macrophage and LAK cell killing.

A requirement for both HLA class I and II binding is that the peptides must contain a binding motif, which usually is different for different HLA groups and subgroups. A binding motif is characterised by the requirement for amino acids of a certain type, for instance the ones carrying large and hydrophobic or positively charged side groups, in definite positions of the peptide so that a narrow fit with the pockets of the HLA binding groove is achieved. The result of this, taken together with the peptide length restriction

of 8-10 amino acids within the binding groove, is that it is quite unlikely that a peptide binding to one type of HLA class I molecules will also bind to another type. Thus, for example, it may very well be that the peptide binding motif for the HLA-A1 and HLA-A2 subgroups, which both belong to the class I gender, are as different as the motifs for the HLA-A1 and HLA-B1 molecules.

For the same reasons it is not likely that exactly the same sequence of amino acids will be located in the binding groove of the different class II molecules. In the case of HLA class II molecules the binding sequences of peptides may be longer, and it has been found that they usually contain from 10 to 16 amino acids, some of which, at one or both terminals, are not a part of the binding motif for the HLA groove.

However, an overlap of the different peptide binding motifs of several HLA class I and class II molecules may occur. Peptides that have an overlap in the binding sequences for at least two different HLA molecules are said to contain "nested T cell epitopes". The various epitopes contained in a "nested epitope peptide" may be formed by processing of the peptide by antigen presenting cells and thereafter be presented to T cells bound to different HLA molecules. The individual variety of HLA molecules in humans makes peptides containing nested epitopes more useful as general vaccines than peptides that are only capable of binding to one type of HLA molecule.

Effective vaccination of an individual can only be achieved if at least one type of HLA class I and/or II molecule in the patient can bind a vaccine peptide either in it's full length or as processed and trimmed by the patient's own antigen presenting cells.

The usefulness of a peptide as a general vaccine for the majority of the population increases with the number of different HLA molecules it can bind to, either in its full length or after processing by antigen presenting cells.

In order to use peptides derived from an abberant protein resulting from mutational events in cells as vaccines ortherapeutic agents to generate CD4+ and/or CD8+ T cells, it is necessary to investigate the mutant protein in question and identify peptides that are capable, eventually after processing to shorter peptides by the antigene presenting cells, to stimulate T cells.

Definition of Problem solved by the Invention.

At present no drug or other treatment is able to eliminate the cells producing the aberrant proteins responsible for the degenerative process in the brain of patients afflicted with Alzheimers disease. There is a continuing need for treatment and prophylaxis of Alzheimer's disease. The present invention will contribute to supply new peptides that can have use as treatment and prophylaxis of Alzheimer's disease. Our approach is aimed at directly eliminating the cells responsible for the degenerative process.

The peptides may also be applicable for treatment of patients with Down syndrome.

Definition of the Invention

A main object of the invention is to obtain peptides corresponding to peptide fragments of aberrant βAPP and

Ubi-B proteins found in Alzheimer's disease and/or Down syndrome patients which can be used to stimulate T cells.

Another main object of the invention is to develop a treatment for Alzheimer's disease based on the T cell immunity which may be induced in patients by stimulating their T cells either *in vivo* or *ex vivo* with the peptides according to the invention.

A third main object of the invention is to develop a vaccine to prevent the establishment of Alzheimer's disease based solely or partly on peptides corresponding to peptides of the present invention which can be used to generate and activate T cells which produce cytotoxic T cell immunity against cells producing the mutant βAPP and mutant Ubi-B proteins.

A fourth main object of the invention is to design a treatment or prophylaxis for Alzheimer's disease specifically adapted to a human individual in need of such treatment or prophylaxis, which comprises administering at least one peptide according to this invention.

A fifth object of the invention is to obtain a treatment for patients with Down syndrome using the same methods as for the treatment of Alzheimer's disease.

These and other objects of the invention are achieved by the attached claims.

Frameshift mutations can occur at the gene level, transcriptional level or by posttranscriptional editing of RNA and result in premature stop codons and therefore a deletion of sometimes large parts of the proteins. Aberrant proteins arising from frameshift mutations have generally

not been considered to be immunogenic and have therefore not been considered as targets for immunotherapy. Thus it has now surprisingly been found that a group of new peptides corresponding to aberrant proteins resulting from frameshift mutations associated with Alzheimer's disease and Down syndrome are useful for eliciting T cell responses against cells producing such aberrant proteins.

Genes containing a mono nucleoside base repeat sequence, for example of deoxyadenosine bases, or a di-nucleoside base repeat sequence, for example of deoxycytosine-deoxythymidine units, are susceptible to frameshift mutations. The frameshift mutations occur, respectively, either by insertion of one or two of the mono-nucleoside base residue or of one or two of the di-nucleoside base unit in the repeat sequence, or by deletion of one or two of the mono-nucleoside base residue or of one or two of the di-nucleoside base unit from the repeat sequence. A frameshift mutation will from the point of mutation encode a protein with a new and totally different amino acid sequence as compared to the normal protein. This mutant protein with the new amino acid sequence at the carboxy end will be specific for all cells in which such frameshift mutations have occurred.

In the remainder of this specification and claims the denomination frameshift mutant peptides will comprise such proteins and peptide fragments thereof.

These peptides are at least 8 amino acids long and correspond to frameshift mutant βAPP and/or Ubi-B protein sequences associated with Alzheimer's disease and/or Down syndrome.

A peptide according to this invention is characterised in that it

a) is at least 8 amino acids long and is a fragment of a mutant βAPP and/or Ubi-B protein arising from a frameshift mutation associated with Alzheimer's disease or Down syndrome;

and

b) consists of at least one amino acid of the mutant part of the mutant βAPP and/or Ubi-B protein;

and

c) comprises 0-10 amino acids corresponding to the carboxyl terminus of the normal part of the protein sequence preceding the amino terminus of the mutant sequence and may further extend to the carboxyl terminus of the mutant part of the protein as determined by a new stop codon generated by the relevant frameshift mutation;

and

d) induces, either in its full length or after processing by antigen presenting cells, T cell responses.

The peptides of this invention contain preferably 8-25, 9-20, 9-16, 8-12 or 20-25 amino acids. They may for instance contain 9, 12, 13, 16 or 21 amino acids.

It is most preferred that the peptides of the present invention are at least 9 amino acids long, for instance

9-18 amino acids long, but due to the processing possibility of the antigen presenting cells also longer peptides are very suitable for the present invention. Thus the whole mutant amino acid sequence may be used as a frameshift mutant peptide according to the present invention, if it comprises 8 amino acids or more.
The invention further relates to a method for vaccination of a person disposed for Alzheimer's disease, consisting of administering at least one peptide of the invention one or more times in an amount sufficient for induction of T-cell immunity to the mutant βAPP and/or Ubi-B proteins.

The invention also relates to a method for treatment of a patient with Alzheimer's disease, consisting of administering at least one peptide of the invention one or more times in an amount sufficient for induction of T-cell immunity to the mutant βAPP and/or Ubi-B proteins.

The invention also relates to a method for treatment of a patient with Down syndrome, consisting of administering at least one peptide of the invention one or more times in an amount sufficient for induction of T-cell immunity to the mutant βAPP and/or Ubi-B proteins.

Detailed Description of the invention.

In the present description and claims, the amino acids are represented by their one letter abbreviation as known in the art.

The peptides of the present invention are exemplified by the βAPP and Ubi-B frameshift mutations associated with Alzheimer's disease and Down syndrome:

In Alzheimer's and Down syndrome patients, intracellular and extracellular deposites of proteins in tangles, neurophil threads and neuritic plaques are correlated with neuronal dysfunction leading to dementia (R.D.Terry et al in *Alzheimer Disease*, R.D.Terry, R.Katzman, K.L.Bick, Eds. (Raven, New York, 1994) pp. 179-196). These protein deposits have been shown to contain forms of β amyloid precursor protein (βAPP) and ubiquitin-B (Ubi-B) that are aberrant in the carboxyl terminus, and it has further been shown that these aberrant protein sequences are results of frameshift mutations which probably occur at the transcriptional level or by posttranscriptional editing of RNA (F.W. van Leeuwen et al, Science,vol 279, pp. 242-247).

In the case of βAPP two frameshift mutations have been observed, one by deletion of the di-nucleoside deoxyguanosine-deoxyadenosine (GA) unit from the (ACC)GAGAGAGA(ATG) sequence in exon 9, and one by deletion of a GA unit from the (CAT)GAGAGA(ATG) sequence in exon 10. The mutant βAPP peptides resulting from these frameshift mutations are shown in table 1. The peptides with seq id nos 1 and 4 are the mutant part of the βAPP protein sequence and the peptides with seq id nos 2, 3 and 5 represent mutant peptides extended into the normal βAPP sequence at the amino terminus.

normal βAPP;	RLEAKHRERMSQVMREWEEAERQAKNLPK
seq id no 1;	NVPGHERMGRGRTSSKELA
seq id no 2;	RLEAKHRENVPGHERMGRGRTSSKELA
seq id no 3;	RLEAKHRENVPGHERMG
seq id no 4;	MGRGRTSSKELA
seq id no 5;	ERMSQVMRMGRGRTS

Table 1.

Also in the case of Ubi-B two frameshift mutations have been observed, one by deletion of the di-nucleoside deoxyguanosine-deoxythymidine (GT) unit from the (TCT)GAGAGGT(GGT) sequence in exon, and one by deletion of a di-nucleoside deoxycytosine-deoxythymidine (CT) unit from the (TCA)CTCT(GGA) sequence in exon 3. The mutant Ubi-B peptides resulting from these frameshift mutations are shown in table 2. The peptides with seq id nos 6 and 9 are the mutant part of the Ubi-B protein sequence and the peptides with seq id nos 7, 8 and 10 represent mutant peptides extended into the normal Ubi-B sequence at the amino terminus.

normal Ubi-B;	HLVLRLRGGMQIFVKTLTGKTITLEVEPSD
seq id no 6;	YADLREDPDRQDHHPGSGAQ
seq id no 7;	HLVLRLRGYADLREDPDRQDHHPGSGAQ
seq id no 8;	HLVLRLRGYADLREDPD
seq id no 9;	GGGAQ
seq id no 10;	TLTGKTITGGGAQ

Table 2.

The mutant βAPP and Ubi-B proteins are only encoded for by cells in which corresponding frameshift mutations have occurred and are therefore targets for specific immunotherapy of Alzheimer's disease and Down syndrome.

According to the present invention, peptides corresponding to mutant βAPP and mutant Ubi-B proteins can be used to elicit T cellular immunity and specific killing of cells producing mutant βAPP and mutant Ubi-B proteins, which in Alzheimer's disease and Down syndrome patients are correlated with neuronal dysfunction leading to dementia.

Other peptides of the invention can be fragments of the peptides listed in the Tables 1 and 2 above. Such fragments are most preferred from 9-16 amino acids long and include at least one amino acid from the mutant part of the protein.

As used in this description and claims the term fragment is intended to specify a shorter part of a longer peptide or of a protein.

Synthesis

The peptides are synthesised by using continuous flow solid phase peptide synthesis. N-a-Fmoc-amino acids with appropriate side chain protection are used. The Fmoc-amino acids are activated for coupling as pentafluorophenyl esters or by using either TBTU or di-isopropyl carbodi-imide activation prior to coupling. 20% piperidine in DMF is used for selective removal of Fmoc after each coupling. Cleavage from the resin and final removal of side chain protection is performed by 95% TFA containing appropriate scavengers. The peptides are purified and analysed by reversed phase (C18) HPLC. The identity of the peptides is confirmed by using electro-spray mass spectroscopy (Finnigan mat SSQ710).

Several other well known methods can be applied by a person skilled in the art to synthesise the peptides.

The peptides of the invention may be used in a method for the treatment of Alzheimer's disease and Down syndrome patients with cells producing frameshift mutant βAPP and Ubi-B proteins, which treatment comprises administering at

least one peptide of the present invention *in vivo* or *ex vivo* to a patient in need of such treatment.

In another embodiment the peptides of the invention may be used to vaccinate a human being disposed for Alzheimer's disease, by administering at least one peptide of the present invention to said human being.

It is further considered to be an advantage to administer to a human a mixture of the peptides of this invention, whereby each of the peptides of the invention can bind to different types of HLA class I and/or class II molecules of the individual.

It is considered that the peptides may be administered together, either simultaneously or separately, with compounds such as cytokines and/or growth factors, i.e. interleukin-2 (IL-2), interleukin-12 (IL-12), granulocyte macrophage colony stimulating factor (GM-CSF), or the like in order to strengthen the immune response as known in the art.

The peptides according to the present invention can be used in a vaccine or a therapeutical composition either alone or in combination with other materials, such as for instance standard adjuvants or in the form of a lipopeptide conjugate which as known in the art can induce high-affinity cytotoxic T lymphocytes, (K. Deres, Nature, Vol.342, (nov.1989)).

The peptides according to the present invention may be useful to include in either a peptide or recombinant fragment based vaccine.

The peptides according to the present invention can be included in pharmaceutical compositions or in vaccines together with usual additives, diluents, stabilisers or the like as known in the art.

According to this invention, a pharmaceutical composition or vaccine may include the peptides alone or in combination with at least one pharmaceutically acceptable carrier or diluent.

Further a vaccine or therapeutical composition can comprise a selection of peptides which are fragments of the mutant βAPP and Ubi-B proteins associated with Alzheimer's disease and Down syndrome.

The vaccine according to this invention may further be administered to the population in general for example as a mixture of peptides giving rise to T cell immunity against cells in which Alzheimer's disease and Down syndrome connected βAPP and Ubi-B frameshift mutations may occur.

The peptides according to this invention may be administered as single peptides or as a mixture of peptides. Alternatively the peptides may be covalently linked with each other to form larger polypeptides or even cyclic polypeptides.

A therapy for Alzheimer's disease and Down syndrome according to the present invention may be administered both *in vivo* or *ex vivo* having as the main goal to elicit specific T cell immunity against the mutant βAPP and Ubi-B gene products associated with Alzheimer's disease and Down syndrome.

Further, the frameshift mutant peptides of this invention may be administered to a patient by various routes including but not limited to subcutaneous, intramuscular, intradermal, intraperitoneal, intravenous or the like. In one embodiment the peptides of this invention are administered intradermally. The peptides may be administered at single or multiple injection sites to a patient in a therapeutically or prophylactically effective amount.

The peptides of this invention may be administered only once or alternatively several times, for instance once a week over a period of 1-2 months with a repeated sequence later, all according to the need of the patient being treated.

The peptides of this invention can be administered in an amount in the range of 1 microgram (1 μg) to 1 gram (1g) to an average human patient or individual to be vaccinated. It is preferred to use a smaller dose in the rage of 1 microgram (1 μg) to 1 milligram (1 mg) for each administration.

The invention further encompasses DNA sequences which encodes a frameshift mutation peptide.

The peptides according to the invention may be administered to an individual in the form of DNA vaccines. The DNA encoding these peptides may be in the form of cloned plasmid DNA or synthetic oligonucleotide. The DNA may be delivered together with cytokines, such as IL-2, and/or other co-stimulatory molecules. The cytokines and/or co-stimulatory molecules may themselves be delivered in the form of plasmid or oligonucleotide DNA. The response to a DNA vaccine has been shown to be increased by the presence

of immunostimulatory DNA sequences (ISS). These can take the form of hexameric motifs containing methylated CpG, according to the formula :
5'-purine-purine-CG-pyrimidine-pyrimidine-3'. Our DNA vaccines may therefore incorporate these or other ISS, in the DNA encoding the peptides, in the DNA encoding the cytokine or other co-stimulatory molecules, or in both. A review of the advantages of DNA vaccination is provided by Tighe et al (1998, *Immunology Today*, 19(2), 89-97).

In one embodiment, the DNA sequence encoding the mutant βAPP and mutant Ubi-B peptides comprises:

Normal βAPP gene sequence (exons 9 and 10).

repeat 1

GAG AGG CTT GAG GCC AAG CAC C**GA GAG AGA** ATG TCC CAG GTC AT**G**

repeat 2

AGA GAA TGG GAA GAG GCA GAA CGT CAA GCA AAG AAC TTG CCT AAA

Mutant βAPP gene sequence, GA deleted from repeat 1.

GAG AGG CTT GAG GCC AAG CAC C**GA GAG A**AT GTC CCA GGT CAT GAG AGA ATG GGA AGA GGC AGA ACG TCA AGC AAA GAA CTT GCC TAA

Mutant βAPP gene sequence, GA deleted from repeat 2.

GAG AGG CTT GAG GCC AAG CAC CGA GAG AGA ATG TCC CAG GTC AT**G** **AGA** ATG GGA AGA GGC AGA ACG TCA AGC AAA GAA CTT GCC TAA

Normal Ubi-B gene (exon) sequence.

deletion motif

CAC CTG GTC CTG CGT CT**G AGA GGT** GGT ATG CAG ATC TTC GTG AAG ACC CTG ACC GGC AAG ACC ATC ACC CTG GAA GTG GAG CCC AGT GAC

Mutant Ubi-B gene sequence, GT deleted from the deletion motif.

CAC CTG GTC CTG CGT CT**G AGA G**GG TAT GCA GAT CTT CGT GAA GAC
CCT GAC CGG CAA GAC CAT CAC CCT GGA AGT GGA GCC CAG TGA

Normal Ubi-B gene (exon 2) sequence.

CAC CTG GTC CTG CGT CTG AGA GGT GGT ATG CAG ATC TTC GTG AAG
CT repeat
ACC CTG ACC GGC AAG ACC ATC A**CT CT**G GAG GTG GAG CCC AGT GAC

Mutant Ubi-B gene sequence, CT deleted from the CT repeat.

CAC CTG GTC CTG CGT CTG AGA GGT GGT ATG CAG ATC TTC GTG AAG
ACC CTG ACC GGC AAG ACC ATC A**CT** GGA GGT GGA GCC CAG TGA

The invention further encompasses vectors and plasmids comprising a DNA sequence encoding at least one frameshift mutant βAPP and/or Ubi-B peptide. The vectors include, but are not limited to *E.Coli* plasmid, a Listeria vector and recombinant viral vectors. Recombinant viral vectors include, but are not limited to orthopox virus, canary virus, capripox virus, suipox virus, vaccinia, baculovirus, human adenovirus, SV40, bovine papilloma virus and the like comprising the DNA sequence encoding a mutant βAPP and/or Ubi-B peptide.

It is considered that a treatment for Alzheimer's disease and Down syndrome, or prophylaxis for Alzheimer's disease, may be achieved also through the administration of an effective amount of a recombinant virus vector or plasmid comprising at least one insertion site containing a DNA sequence encoding a frameshift mutant peptide to a patient,

whereby the patient's antigen presenting cells are turned into host cells for the vector/plasmid and presentation of HLA/frameshift mutant peptide complex is achieved.

A person skilled in the art will find other possible use combinations with the peptides of this invention, and these are meant to be encompassed by the present claims.

The peptides according to this invention may be produced by conventional processes as known in the art, such as chemical peptide synthesis, recombinant DNA technology or protease cleavage of a protein or peptide encoded by frameshift mutated βAPP gene and Ubi-B gene. One method for chemical synthesis is elucidated in the description below.

Through the present invention the following advantages are achieved:

It offers a possibility to treat patients suffering from Alzheimer's disease and Down syndrome connected with frameshift mutant βAPP and Ubi-B gene products, who known at present do not have any good treatment alternatives.

Furthermore it offers a possibility to vaccinate humans prophylaxtically against the onset of Alzheimer's disease.

Claims

1. A peptide c h a r a c t e r i s e d in that it

a) is at least 8 amino acids long and is a fragment of a mutant βAPP and/or Ubi-B protein arising from a frameshift mutation associated with Alzheimer's disease and/or Down syndrome;

and

b) consists of at least one amino acid of the mutant part of the mutant βAPP and/or Ubi-B protein;

and

c) comprises 0-10 amino acids corresponding to the carboxyl terminus of the normal part of the protein sequence preceding the amino terminus of the mutant sequence and may further extend to the carboxyl terminus of the mutant part of the protein as determined by a new stop codon generated by the relevant frameshift mutation;

and

d) induces, either in its full length or after processing by antigen presenting cells, T cell responses.

2. A peptide according to claim 1 characterised in that it contain 8-25 amino acids.

3. A peptide according to claim 1 characterised in that it contain 9-20 amino acids.

4. A peptide according to claim 1 characterised in that it contain 9-16 amino acids.

5. A peptide according to claim 1 characterised in that it contain 8-12 amino acids.

6. A peptide according to claim 1 characterised in that it contain 20-25 amino acids.

7. A peptide according to claim 1 characterised in that it contains 9 amino acids.

8. A peptide according to claim 1 characterised in that it contains 12 amino acids.

9. A peptide according to claim 1 characterised in that it contains 13 amino acids.

10. A peptide according to claim 1 characterised in that it is selected from a group of peptides having the following sequence identity numbers:
seq id no. 1 - seq id no. 10 or a fragment of any of these.

11. A pharmaceutical composition comprising a peptide according to any of the above claims and a pharmaceutically acceptable carrier or diluent.

12. A vaccine for Alzheimer's disease comprising a peptide according to any of the claims 1-10 and a pharmaceutically acceptable carrier or diluent.

13. Use of a peptide according to any of the claims 1-10 for the preparation of a pharmaceutical composition for treatment or prophylaxis of Alzheimer's disease or treatment of Down syndrome.

14. Method for vaccination of a person disposed for or afflicted with Alzheimer's disease, consisting of administering at least one peptide according to the claims 1-10, one or more times, in an amount sufficient for induction of specific T-cell immunity to mutant βAPP and/or mutant Ubi-B peptides associated with Alzheimer's disease and/or Down syndrome.

15. Method according to claim 14 wherein the amount of the peptides is in the range of 1 microgram (1 µg) to 1 gram (1g) and preferentially in the rage of 1 microgram (1 µg) to 1 milligram (1 mg) for each administration.

16. Method for treatment of a patient afflicted with Alzheimer's disease or Down syndrome, by stimulating *in vivo* or *ex vivo* with peptides according to the claims 1-10.

17. Method according to claim 16 wherein the amount of the peptides used is in the range of 1 microgram (1 µg) to 1 gram (1g) and preferentially in the rage of 1 microgram (1 µg) to 1 milligram (1 mg) for each administration.

18. An isolated DNA sequence comprising a DNA sequence or variants thereof encoding a frameshift mutant peptide according to claim 1.

19. An isolated DNA sequence according to claim 18 encoding peptides comprising seq. id. no: 1-10 or variants thereof.

20. Use of a DNA sequence according to any of the claims 18-19 for the preparation of a pharmaceutical composition for treatment or prophylaxis of Alzheimer's disease or treatment of Down syndrome.

21. Method for treatment of a person disposed for or afflicted with Alzheimer's disease or afflicted with Down syndrome, by stimulating *in vivo* or *ex vivo* with DNA sequences according to the claims 18-19.

22. A plasmid or virus vector comprising DNA sequences of claim 18 encoding a frameshift mutant βAPP peptide and/or Ubi-B peptide associated with Alzheimer's disease or Down syndrome.

23. A vector according to claim 22 wherein the vector is *E.Coli* plasmid, a Listeria vector and recombinant viral vectors. Recombinant viral vectors include, but are not limited to orthopox virus, canary virus, capripox virus, suipox virus, vaccinia, baculovirus, human adenovirus, SV40 or bovine papilloma virus.

24. Use of a plasmid or virus vector according to claim 22 for the preparation of a pharmaceutical composition for treatment or prophylaxis of Alzheimer's disease or treatment of Down syndrome.

25. Method for treatment of a person disposed for or afflicted with Alzheimer's disease or afflicted with Down syndrome, by stimulating *in vivo* or *ex vivo* with plasmids or virus vectors according to claim 22.

SEQUENCE LISTING

COMMON FOR ALL SEQUENCES.

SEQUENCE TYPE: Peptide

SEQUENCE UNIT: Amino Acid

TOPOLOGY: Linear

SEQUENCE ID NO: 1

SEQUENCE LENGTH: 19 amino acids

N V P G H E R M G R G R T S S K E L A

1 5 10 15

SEQUENCE ID NO: 2

SEQUENCE LENGTH: 27 amino acids

R L E A K H R E N V P G H E R M G R G R T S S K E L A

1 5 10 15 20 25

SEQUENCE ID NO: 3

SEQUENCE LENGTH: 17 amino acids

R L E A K H R E N V P G H E R M G

1 5 10 15

SEQUENCE ID NO: 4

SEQUENCE LENGTH: 12 amino acids

M G R G R T S S K E L A

1 5 10

SEQUENCE ID NO: 5

SEQUENCE LENGTH: 15 amino acids

E R M S Q V M R M G R G R T S

1 5 10 15

SEQUENCE ID NO: 6

SEQUENCE LENGTH: 20 amino acids

Y A D L R E D P D R Q D H H P G S G A Q

1 5 10 15 20

SEQUENCE ID NO: 7

SEQUENCE LENGTH: 28 amino acids

H L V L R L R G Y A D L R E D P D R Q D H H P G S G A Q

1 5 10 15 20 25

SEQUENCE ID NO: 8

SEQUENCE LENGTH: 17 amino acids

H L V L R L R G Y A D L R E D P D

1 5 10 15

SEQUENCE ID NO: 9

SEQUENCE LENGTH: 5 amino acids

G G G A Q

1 5

SEQUENCE ID NO: 10

SEQUENCE LENGTH: 13 amino acids

T L T G K T I T G G G A Q

1 5 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO 99/00141

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: C07K 14/435, A61K 39/00
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: C07K, A61K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 9712992 A2 (ROYAL NETHERLANDS ACADEMY OF ARTS AND SCIENCES ET AL), 10 April 1997 (10.04.97), table 7 --	1-25
X	SCIENCE, Volume 279, January 1998, Fred W. van Leeuwen et al, "Frameshift Mutans of beta Amyloid Precursor Protein and Ubiquitin-B in Alzheimer's and Down Patients" page 242 - page 247 --	1-26
X	WO 9532731 A2 (THE CHANCELLOR MASTERS AND SCHOLARS OF THE UNIVERSITY OF OXFORD ET AL), 7 December 1995 (07.12.95), page 3, line 8 - page 4, line 26 --	11-25

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 October 1999	22 -10- 1999
Name and mailing address of the ISA/ Swedish Patent Office, Box 5055, S-102 42 STOCKHOLM, Facsimile No. + 46 8 666 02 86	Authorized officer: Patrick Andersson/ELY, Telephone No. + 46 8 782 25 00

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO 99/00141

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	WO 9845322 A2 (ROYAL NETHERLANDS ACADEMY OF ARTS AND SCIENCES ET AL), 15 October 1998 (15.10.98), claim 24 and the whole document -- --------	1-25

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO99/00141

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☒ Claims Nos.: 14-17,21 and 25
because they relate to subject matter not required to be searched by this Authority, namely:

See extra sheet

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO99/00141

Claims 14-17,21 and 25 relates to methods of treatment of the human or animal body by therapy practised on the human or animal body/ Rule 39.1.(iv). Nevertheless, a search has been executed for these claims. The search has been based on the alleged effects of the compounds/compositions.

INTERNATIONAL SEARCH REPORT

Information on patent family members

28/09/99

International application No.
PCT/NO 99/00141

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9712992 A2	10/04/97	AU 7142796 A	28/04/97
		GB 9520080 D	00/00/00
WO 9532731 A2	07/12/95	AU 2623795 A	21/12/95
		EP 0762891 A	19/03/97
		GB 9410922 D	00/00/00
		JP 10504702 T	12/05/98
WO 9845322 A2	15/10/98	AU 7071598 A	30/10/98